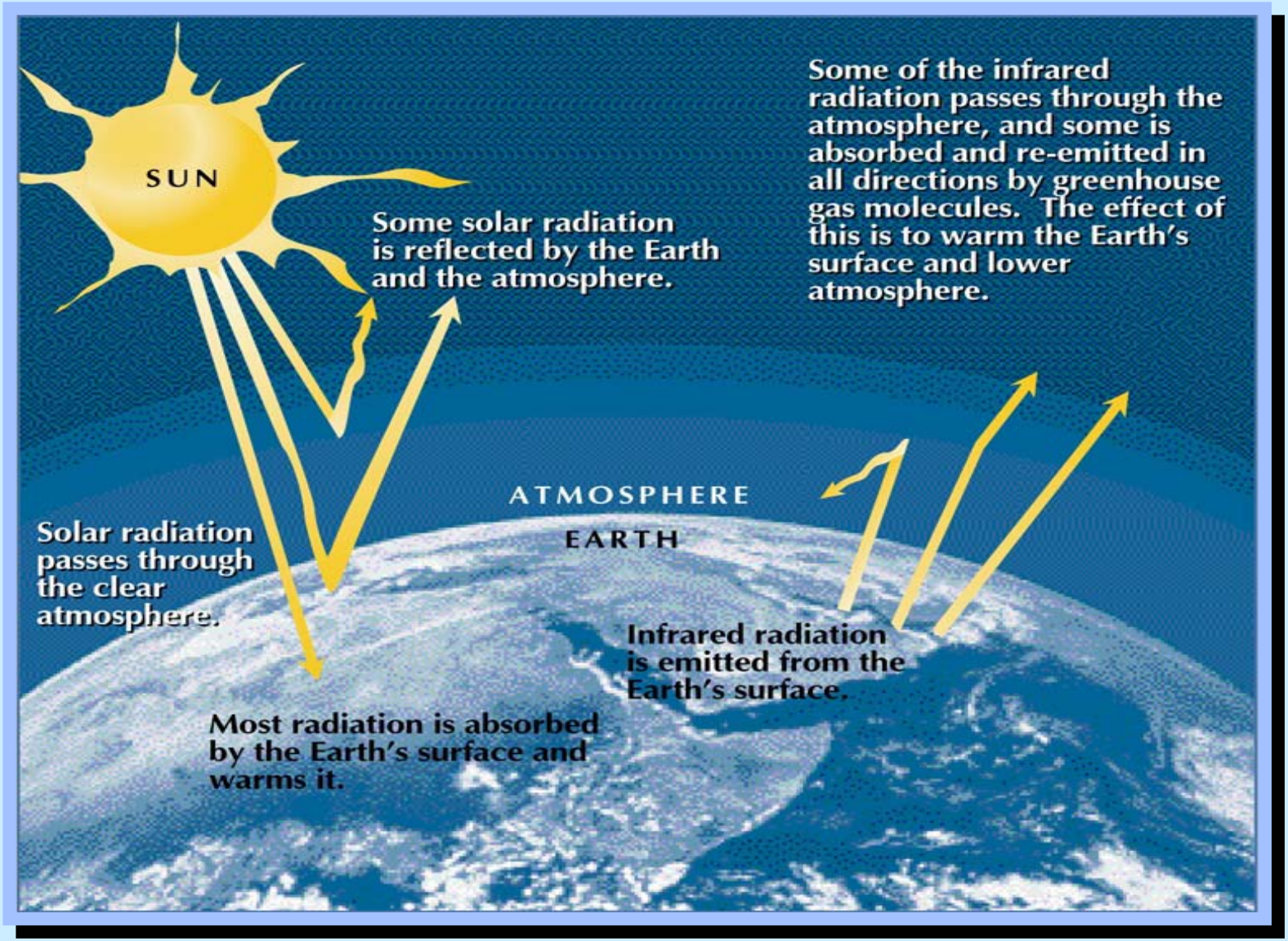
Global Warming and Greenhouse Gas Emissions

Overview

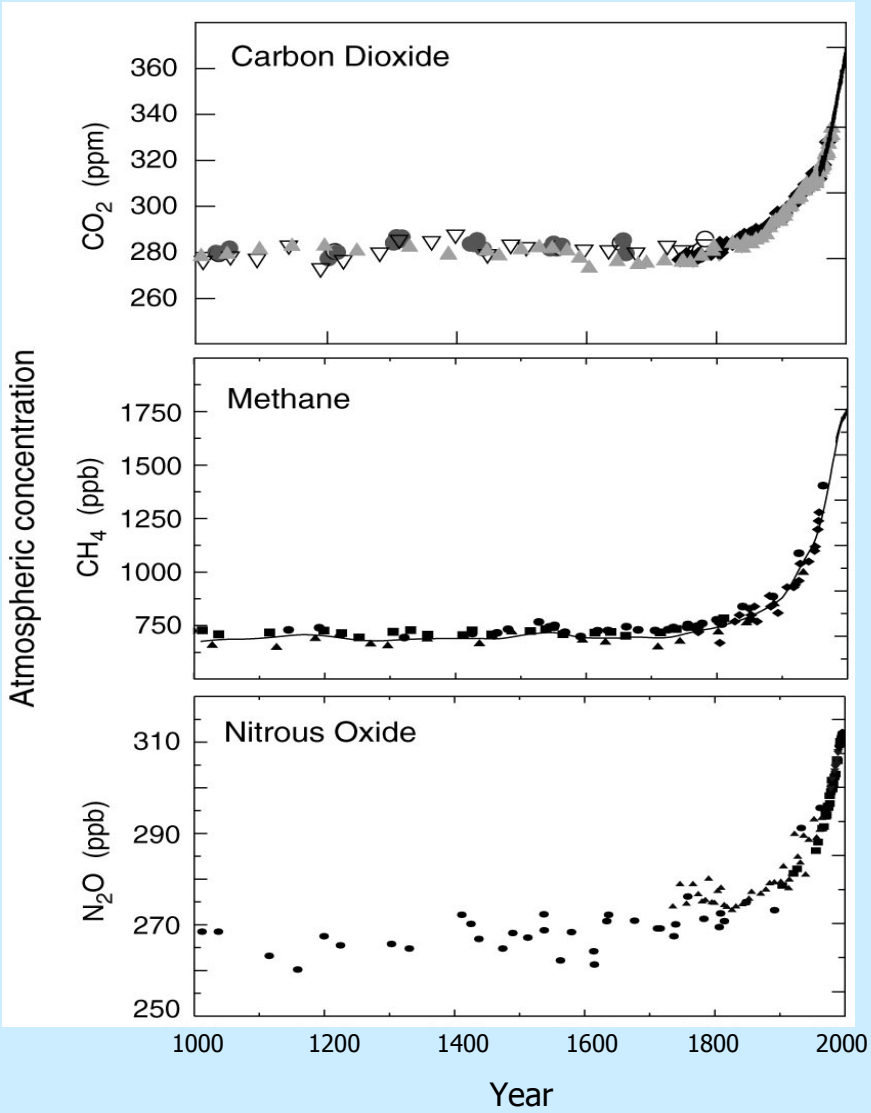
1. Evidence for global warming
2. Potential climate change impacts
3. ARB research activities
4. Summary

The Greenhouse Effect



Source: U.S. EPA State and Local Climate Change Outreach Kit, March 2000

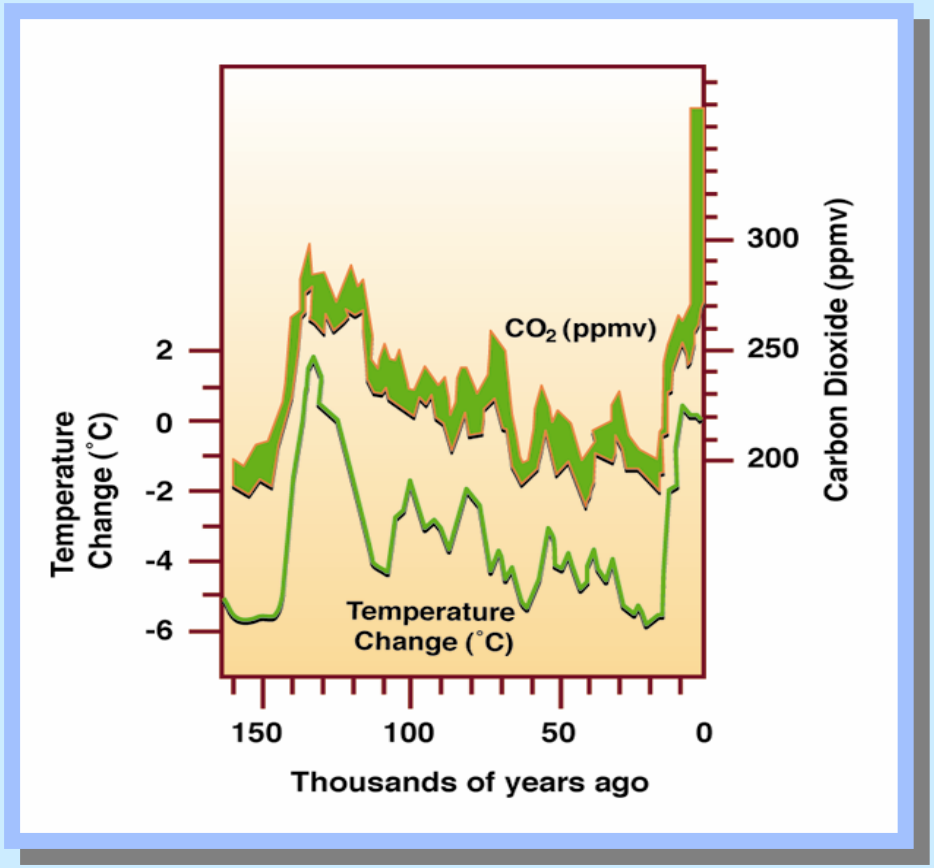
Industrial Era Has Changed the Atmosphere



- **Carbon dioxide, methane, nitrous oxide, particulate matter, and other pollutants cause global warming**
- **IPCC concludes increases in these gases are a result of human activities**

Source: IPCC Report: Summary for Policy Makers, Climate Change 2001: The Scientific Basis

Temperature and Carbon Dioxide Are Related

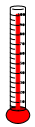


- **Ice core records show the current rate of increase and levels are unprecedented**

Source: Adapted from Office of Science and Technology Policy, Climate Change State of Knowledge, October 1997

Potential Climate Change Impacts

Climate Changes



Temperature Increase

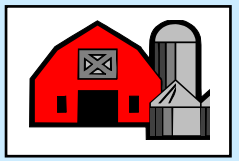
Precipitation Patterns and Extremes

Sea Level Rise

Source: Anne Grambsch, 1998

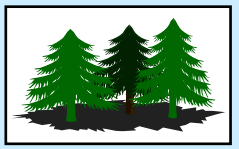
Health

Air Quality - Respiratory Illness
Weather-related Mortality
Infectious and Tropical Diseases



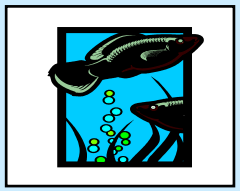
Agriculture

Crop Yields
Irrigation Demands



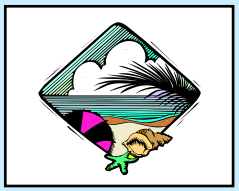
Forests

Forest Composition
Geographic Range of Forests
Forest Health and Productivity



Water Resources

Water Supply
Water Quality
Competition for Water



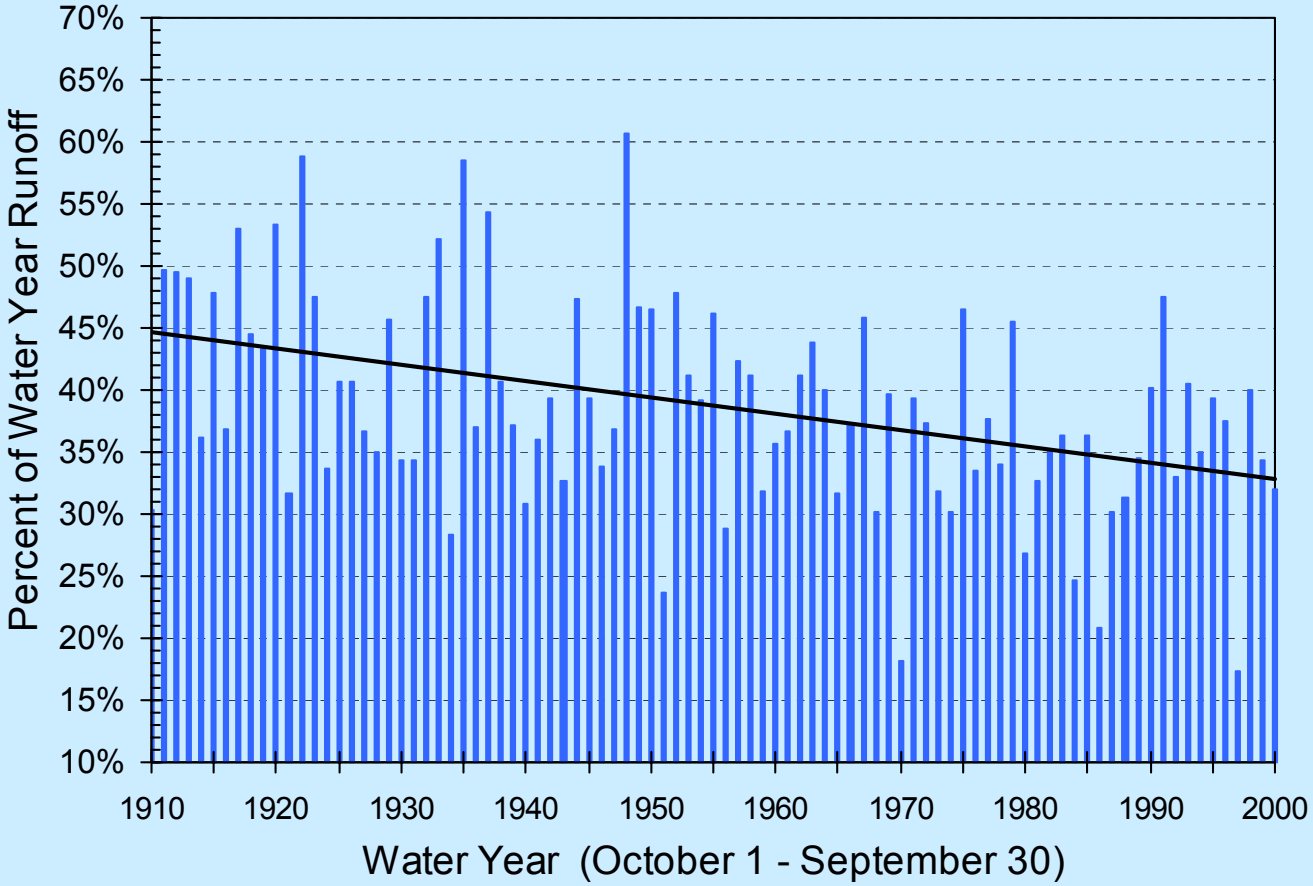
Coastal Areas

Erosion of Beaches
Inundation of Coastal Wetlands
Additional Costs to Protect
Coastal Communities

Species and Natural Areas

Loss of Habitat and Species

Our Principal Reservoir - The Sierra Snow Pack - is Shrinking



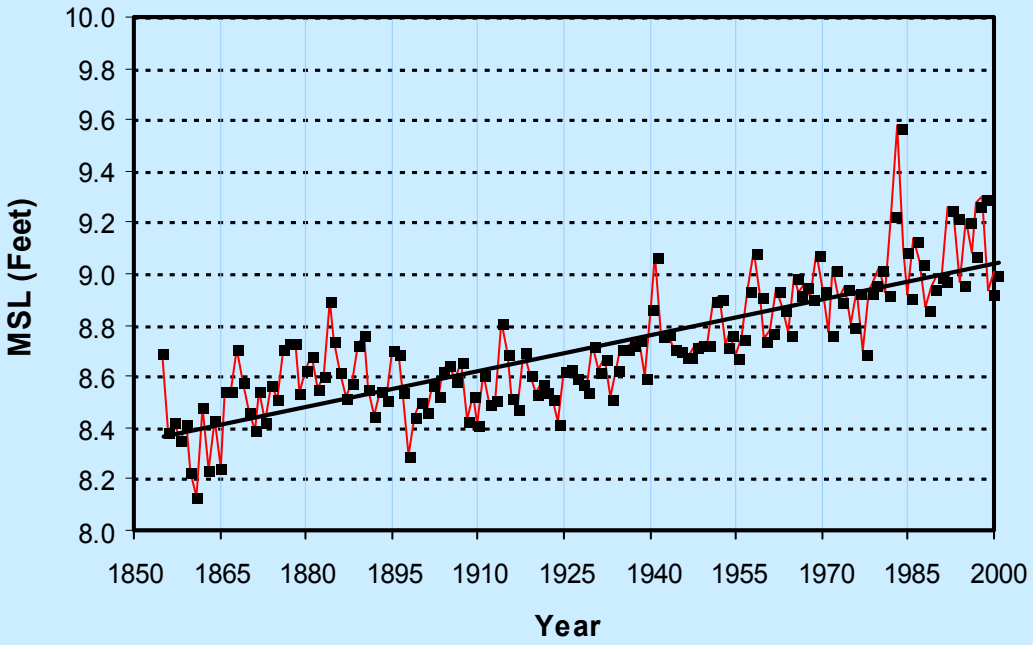
Warmer Winters Have:

- **Reduced snow pack**
- **Led to earlier snow melt**
- **Decreased spring runoff by 10%**
- **Affected water supply**

Sacramento River Runoff (1910-2000) - April to July as a Percent of Total Runoff

Source: Department of Water Resources, 2001

Sea Level is Rising Along California's Coast

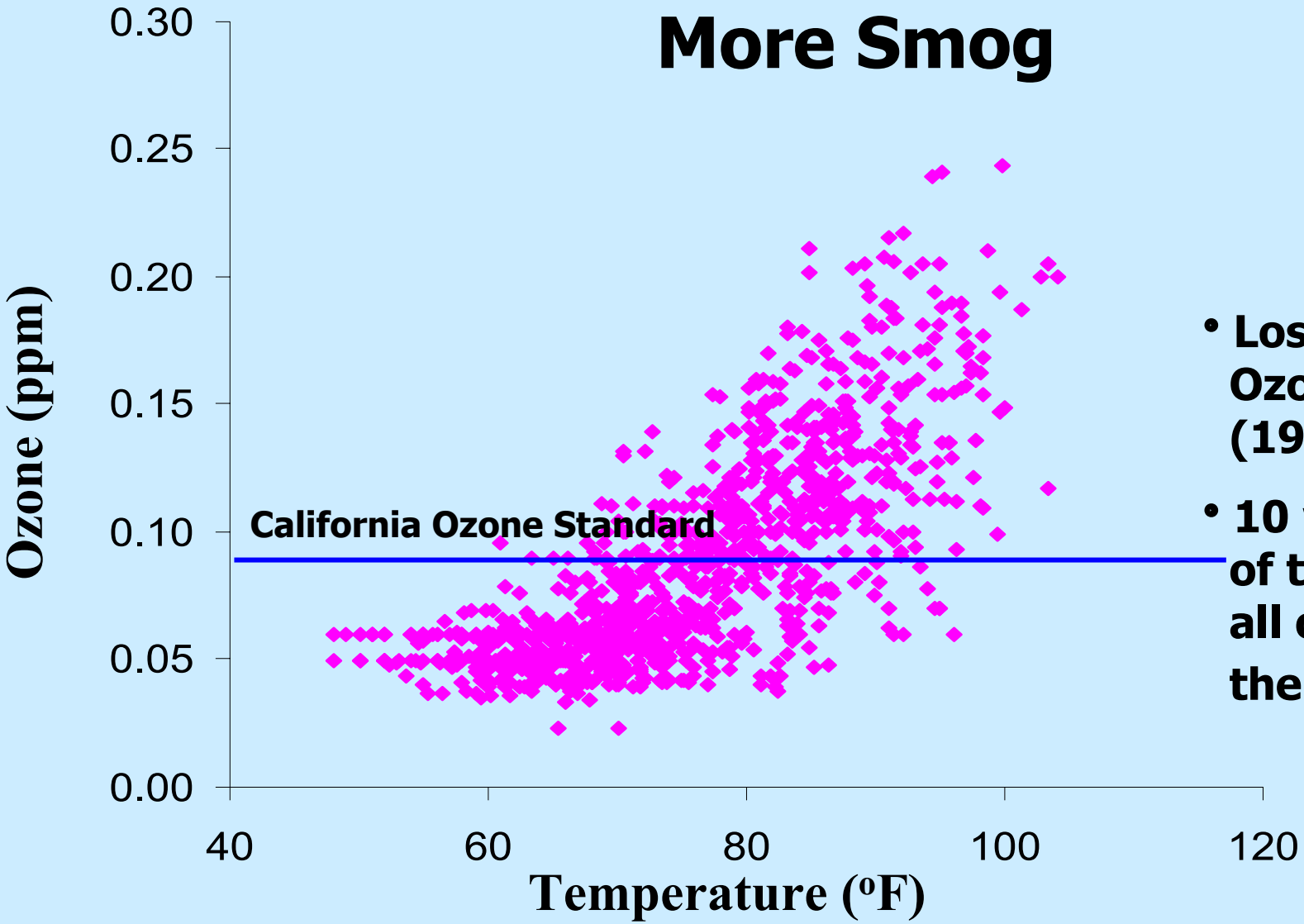


San Francisco Yearly Mean Sea Level (1855-2000)

- **Sea level has already risen 7" in 150 years**
- **Levee stability and salt water intrusion concerns**
- **IPCC projects 4-12" sea level rise by 2050**
- **Present Delta system may not be viable with 8-12" sea level rise**

Source: Department of Water Resources, 2001

Hotter Days Lead to Higher Emissions and More Smog



- Los Angeles Ozone Levels (1995-1998)
- 10 warmest years of the last century all occurred within the last 15 years.

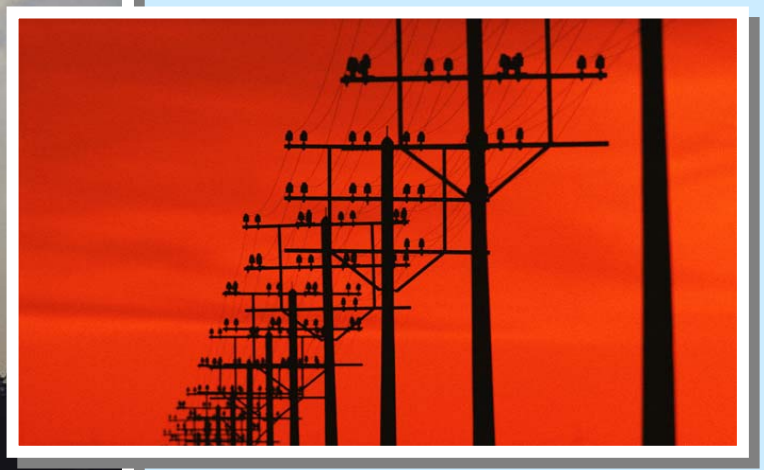
Source: Air Resources Board, 2000

Source: California Environmental Protection Agency

Human Activities Can Intensify the Greenhouse Effect

Transportation

Industry

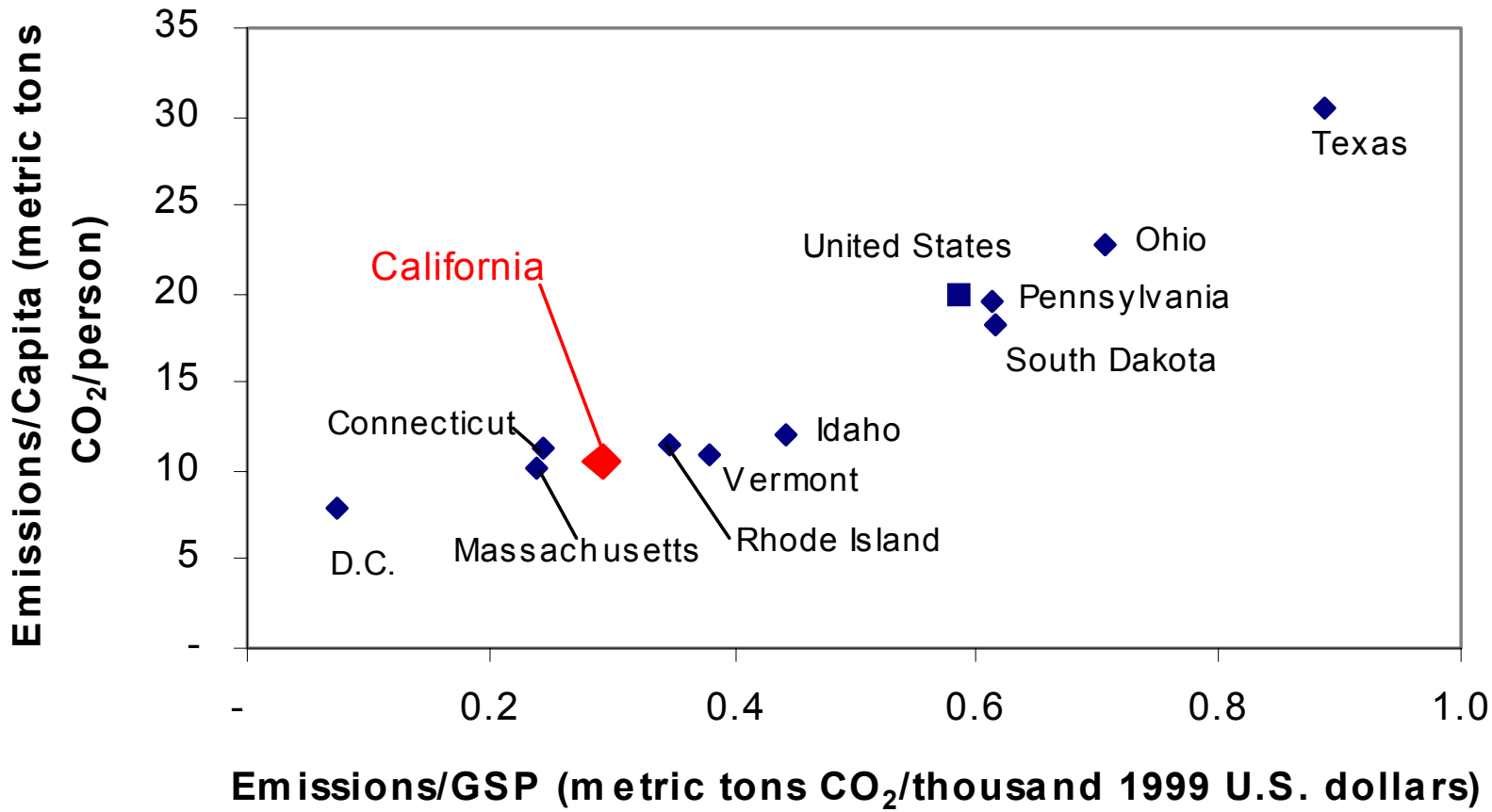


Utilities

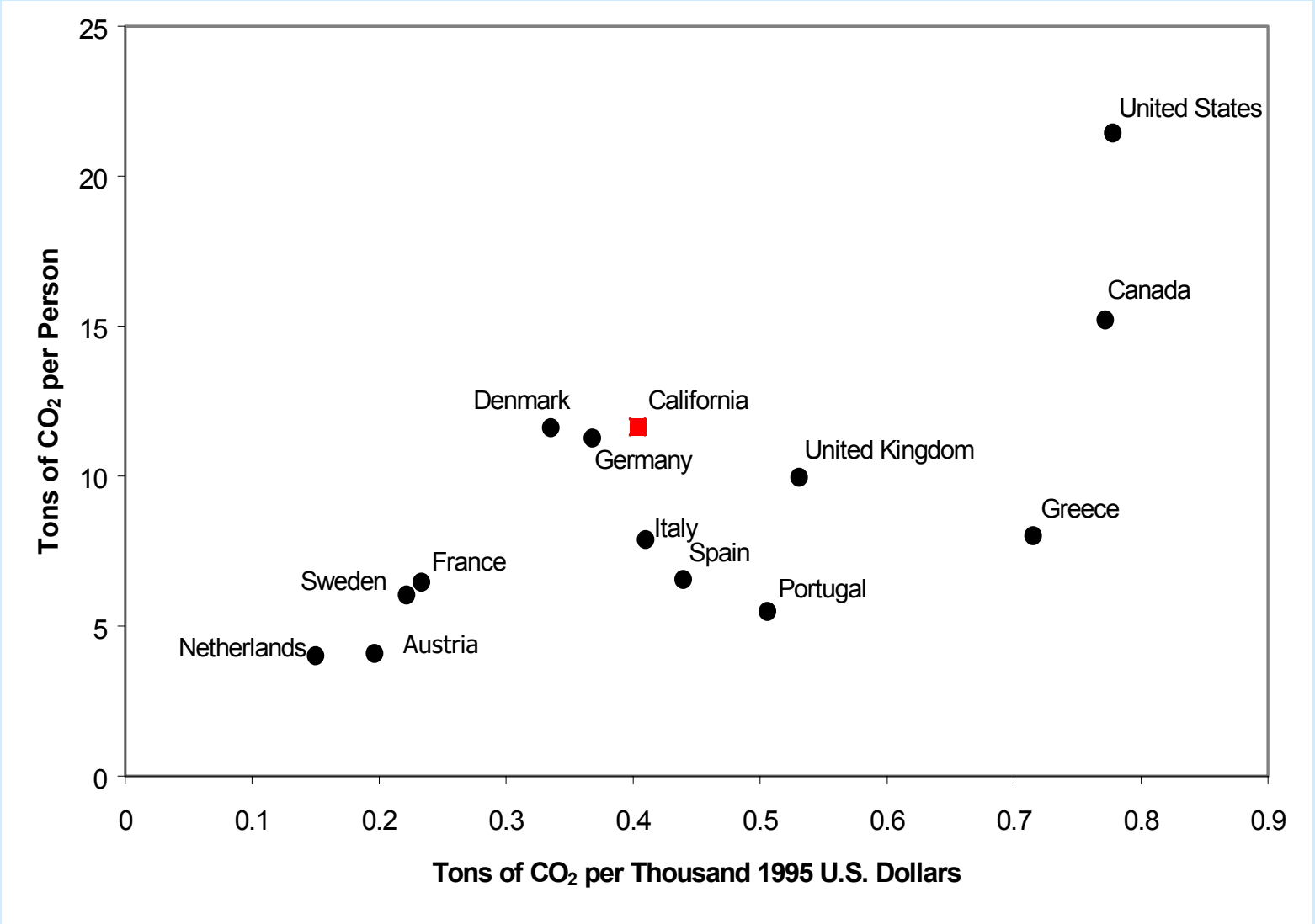
Source: U.S. EPA State and Local Climate Change Outreach Kit, March 2000

California has reduced the growth of CO_2 emissions ...

Carbon Intensities for California and Selected States - 1995



Carbon Intensities for California and Selected Countries - 1995



On-Going Research and Inventory Development

- N_2O
- HFCs
- Black Carbon

N_2O Emissions

N_2O Emissions Current Database

- **N_2O emissions inventory based on ~40 LD vehicles tested at the ARB HSL**
  - The database does not include 'forward-looking' technology vehicles
- **Additional N_2O emissions data are being collected**

N_2O Vehicle Emissions Testing Project

- **A new project is being conducted at the ARB's HSL**
  - Project team includes ARB staff and staff from UCLA
  - Testing is part of the 17th ARB Vehicle Surveillance Project

N_2O Vehicle Emissions Testing Project (con't.)

- N_2O emissions to be characterized using a Fourier Transform Infrared (FTIR) spectroscopy instrument
- Size and composition of test fleet will expand existing data set

N_2O Vehicle Emissions Testing Project (con't.)

- **Project Schedule and Milestones**
  - **Project start date: Spring 2003**
  - **Data collection: Spring 2003 - Fall 2004**
  - **Data analysis: ongoing throughout the project to support AB 1493 milestones**

HFC Emissions

HFC Emissions Sources

- **Two vehicle-related sources of HFC emissions have been identified:**
  - Vehicle A/C system HFC emissions

    ↑ HFC leakage from the vehicle's A/C system
  - Servicing and disposal HFC emissions

    ↑ emissions occur when a vehicle's A/C is disturbed for servicing or at the end of the vehicle's useful life (disposal emissions)

HFC Emissions from Mobile Air Conditioners

- **Available Vehicle HFC emissions Data**
  - "R-134a Emissions from Vehicles" ES&T paper by Siegl, et al (2002)
  - Two-day static SHED test of 28 light-duty gasoline vehicles
    - ↑ HFC emissions exhibited large standard deviation
    - ↑ No measurements of servicing or disposal HFC emissions

HFC Emissions from Mobile Air Conditioners (con't.)

- **Estimating HFC emissions from survey data**
  - Mobile Air Conditioning Society (MACS) Survey - service garage survey
  - Oko-Recharche Survey - service garage survey

Forthcoming Research

- Collect current data from repair shops
  - Recharge frequencies, failure types, recharge rates, etc.
- Survey of CalEPA employees
  - Frequency of service needs
- Emission testing
  - Vehicles Surveillance Project - leak rates from vehicles as a function of AC operation
- Estimate lifetime emissions from a "typical" vehicle (to be defined)

Forthcoming Research (Cont.)
AC Technology Assessment

- Current R134a systems
- Expected improvements, alternatives to R134a system
  - **Factors to consider**
    - Energy efficiency
    - Life-cycle GHG emissions
    - Cost and Safety
    - Technical prospects - potential date of commercialization
- Public workshop (Technology), October 2003

Black Carbon Emissions

Black Carbon (BC) Emission Sources in California

- **Primary sources**
  - On-road and off-road diesel
  - Gasoline vehicles
  - Residential combustion
  - Biomass Burning

Light Duty Vehicle BC Emissions

- **Previous Studies**
  - Caldecott Tunnel, Dr. Harley 1996
  - CE-CERT, Dr. Norbeck
    - 10 Gas LDV (MY 1979-1994) BC emission
    - 40 gas LDV and 19 Diesel Passenger Vehicles
  - Caltech - Dr. Cass 1996
  - UC Davis, Dr. Kleeman 2002
    - 35 light-duty Vehicles (included MY 1999-2002)

BC Emission Inventory Development

- **Motor vehicles emission estimates**
  - Review existing data
    - ↑ Compile existing MV- PM emissions data
    - ↑ Compile emission factors and PM speciation factors used to develop BC inventories
  - Estimate PM Emissions
    - ↑ Estimate fuel-specific (i.e., gasoline and diesel) motor vehicle emissions for climate forcing PM pollutants

Radiative Forcing Effect of BC

- **Caltech Research Project**
  - **Calculate Radiative Forcing**
  - **Apply a global climate model to estimate the relative climate forcing of CO_2, BC, $SO_4^=$, NO_3^-, and OC emissions from different motor vehicle fleets on both short and long timescales**

Radiative Forcing Effect of BC

- **Project Schedule and Milestones**
  - **Project start date: July 2003**
  - **Calculate Radiative Forcing: January 2004**
  - **Data for AB 1493 available in Spring 2004**

Where Are We Headed?

- Incorporate additional research data into inventory
- Compare with other databases
- Next inventory workshop in September 2003

Summary

- Global climate change is a concern
- Need more progress towards reducing greenhouse gas emissions
- AB 1493 requires the Board to set emission standards for greenhouse gases from light-duty mobile sources